What Goes Up Must Come Down: A Lesson on Atmospheric Deposition

Lesson Objective: Students will learn about air quality impacts on the environment by applying point and nonpoint air pollution sources to a "watershed", then conceptualize the impact of air pollution on land and water through atmospheric deposition of "rain" and "snow".

Key Concepts: atmospheric deposition, precipitation; environmental sciences; physical, biological, and chemical processes; nitrogen, sulfur, mercury, pesticides, toxic contaminants; acid rain; artificial fertilization.

Duration: 30 minutes

Audience: Middle school. The activity can be tweaked for use at both the elementary school and high school levels.

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Background:

Although of separate "spheres", the atmosphere (air), hydrosphere (water), biosphere (life), and lithosphere (stone) are connected by the complex processes that include the water cycle, atmospheric chemistry and transport patterns, food webs, and weathering rates of rocks and minerals. Atmospheric deposition, a natural physical process by which airborne contaminants leave the atmosphere and are transferred to the land and water, is one such example that links air, land, and water quality, and subsequently the health of the ecosystem.

It is increasingly evident that air pollution control programs aimed at addressing issues such as acid rain, ozone, and fine particulate matter can also provide significant benefits to water quality. For example, reductions in nitrogen oxide emissions have helped reduce nitrogen eutrophication in coastal waters, while controls on mercury emissions into the atmosphere help reduce methylmercury concentrations in fish and wildlife.

Atmospheric deposition occurs when pollutants are transferred from the air to the earth's surface. Given greater levels of deposition (i.e., snow or rain fall) at higher elevations, airborne pollutants tend to accumulate at high latitudes and high elevations, which are oftentimes remote areas of the globe. Likewise, atmospheric deposition may be especially concentrated in areas near to emission source regions. Terrestrial and aquatic effects may be magnified by the inability of the surrounding landscape to buffer the pollutants, perhaps due to bedrock composition, short growing season, or thin soils.

Atmospheric deposition of nitrogen and sulfur has lead to both acidification and fertilization in certain park ecosystems, which may ultimately result in shifts in plant community composition, fish kills, and loss of biodiversity. Accumulation of airborne contaminants such as mercury and other toxic pollutants in aquatic foodwebs and its effects on aquatic biota are of growing concern both for the health of the fish and the piscivores that prey upon them. This activity demonstrates the connectivity between air, land, and water quality, illustrating how pollutants can be atmospherically deposited and a source of contamination or impact to the ecosystem.

Materials:

1. 3-D Relief Map, "Denver's Playground", or a similar plastic relief map of your local area
    a. If no relief map is available, students can make their own "crumplesheds" using a piece of paper crumpled up, then opened. Peaks, ridges, and valleys are then represented by wrinkles in the paper.
2. Script and associated pictures
3. "Pollution" shakers – with a plastic relief map, ideal to use different colored Kool-Aid flavors to represent different sources of pollution. Salt & pepper shakers work well to dispense the "pollution" among the landscape.
    a. With "crumplesheds", use water-soluble markers to depict different sources of pollution. (The use of water-soluble markers is important here.)
4. Spray bottles

Activity/Procedure:

1. Divide students into groups of 3-5 each. Each group will need the above materials.
2. Consider questions: What are some sources of pollution to your local creek, river, or lake? What are some potential pollutants that may affect creeks, rivers, or lakes at remote, high elevations? Where might those pollutants come from?
3. Project the script and pictures on a screen, and advance through the slides of varying pollution sources. After each source is recorded, instruct a volunteer in the group to "shake" a pollutant on a high elevation area of the relief map. This act depicts (technically, dry) deposition.
    a. If "crumplesheds" and water-soluble markers are the preferred alternative, each student or group of students can take turns depicting a particular pollution source on their crumpleshed.
4. Use different shakers to add varying colors to the enviroscape, effectively enhancing the effects of atmospheric deposition. After all the ingredients have been dumped, have volunteers use the spray bottles to "rain" on the land. Observe what happens.
    a. Similarly, different-colored water-soluble markers can be used to represent different pollution sources. Once the script is complete, spray bottles can be used over the crumplesheds.
5. Answer the assessment questions, below.

Assessment (Student Copy):

1. Referring to atmospheric pollutants that may enter the environment, and indicating where each came from, fill in the blanks. Use a different pollutant and different source for each.

    - Nitrogen from _____
    - Mercury from _____
    - _____ from Agricultural fields

2. Name a potential terrestrial or aquatic effect from the following pollutants

    - Mercury _____
    - Sulfur _____

3. Name two living organisms living in a creek or lake that could be harmed by atmospheric deposition:

    -
    -

4. What can you do to help safeguard the terrestrial and aquatic ecosystems from the ill effects of atmospheric deposition?